

## DOCUMENT RESUME

ED 241 302

SE 043 995

**AUTHOR** Blosser, Patricia E., Ed.; Helgeson, Stanley L., Ed.

**TITLE** National Association for Research in Science Teaching Annual Conference, Abstracts of Presented Papers (57th, New Orleans, Louisiana, April 28-30, 1984).

**INSTITUTION** ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.

**SPONS AGENCY** National Inst. of Education (ED), Washington, DC.

**PUB DATE** 31 Dec 83

**CONTRACT** 400-78-0004

**NOTE** 158p.

**AVAILABLE FROM** ERIC/SMEAC, The Ohio State University, 1200 Chambers Rd., Room 310, Columbus, OH 43212 (\$5.50).

**PUB TYPE** Collected Works - Conference Proceedings (021) -- Information Analyses - ERIC Information Analysis Products (071)

**EDRS PRICE** MF01/PC07 Plus Postage.

**DESCRIPTORS** \*Academic Achievement; \*Cognitive Development; Cognitive Processes; Curriculum Development; Elementary Secondary Education; Higher Education; Microcomputers; Process Education; Research Methodology; Science Curriculum; \*Science Education; \*Science Instruction; \*Student Characteristics; Teacher Characteristics; \*Teacher Education

**IDENTIFIERS** \*Science Education Research

**ABSTRACT**

Abstracts of most of the papers presented at the 57th Annual Meeting of the National Association for Research in Science Teaching (NARST) have been collected in this publication. Papers focus on such areas as cognitive structure, development of scientific literacy in secondary schools, science teaching as a career, improving science teaching, factors influencing attitudes toward science, teacher characteristics and student performance, intellectual development, concept learning, factors influencing achievement, test construction, science instruction, learning science in out-of-school settings, changing and assessing teacher attitudes, and research methods. Other papers focus on areas dealing with learning in chemistry, science teaching in higher education, microcomputers in the classroom, science curriculum development, cognitive teacher behavior, applying teacher effectiveness findings to preservice and inservice teacher education, inservice teacher education, science process skills, cognitive development and science achievement, secondary analysis results from the 1981-82 National Assessment in Science, spatial learning, problem solving, attitudes toward science, science learning in the elementary school, science for gifted and talented students, and misunderstanding of science concepts. (JN)

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NATIONAL ASSOCIATION  
FOR  
RESEARCH IN SCIENCE TEACHING  
57TH ANNUAL NARST CONFERENCE  
1984

Monteleone Hotel

April 28-30, 1984



Clearinghouse for Science, Mathematics  
and Environmental Education  
The Ohio State University  
1200 Chambers Road, Room 310  
Columbus, Ohio 43212

December 31, 1983

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## P R E F A C E

The ERIC Clearinghouse for Science, Mathematics and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 57th annual conference in New Orleans, Louisiana, April 28-30, 1984.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Ertle Thompson and the NARST Program Committee who obtained the abstracts and organized the program, and to Mrs. Linda Shinn for her assistance in preparing the final copy.

Many of the papers will be published in journals or made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Rodney L. Doran  
NARST Research Coordinator

Patricia E. Blosser,  
Stanley L. Helgeson,  
Editors



This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or U.S. Department of Education.

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The gap between the promise of computers in science education and the reality of their use (or disuse) in classrooms looms large. The cognitive consequences of computer learning in science are often mitigated by practical realities such as limited teacher training, poor software, and little hardware. The fulfillment of the promise also requires educational research and policy analysis.

Several projects provide research results and preliminary policy implications from studies of computer learning in science classes. Three different types of cognitively demanding science-related software used under different instructional conditions are reported. Policy implications for instructional design and for use of computers in the classroom are discussed.

A COMPARISON OF COGNITIVE DEVELOPMENT, FIELD INDEPENDENCE/  
DEPENDENCE COGNITIVE STYLE, AND ACADEMIC SUCCESS OF  
BACCALAUREATE NURSING STUDENTS

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This study investigated the relationship among cognitive development, field independence/dependence cognitive style, and academic success of baccalaureate nursing students. Although extensive research activities have been directed at the identification of factors associated with the high rate of nursing student attrition, as well as numerous studies which have sought to identify correlates of academic success, none has prescribed an acceptable solution. Prior research has failed to identify individual attributes which are highly correlated to academic performance of nursing students.

The paid volunteer sample consisted of 54 junior level nursing students recruited from one baccalaureate nursing program. Cognitive development was measured by the scores on a videotaped version of the Classroom Test of Formal Operations. The Group Embedded Figures Test was used to evaluate the level of field independence/dependence. The cumulative grade-point average of the three nursing courses which constitute full-time study in the first semester of the nursing program was considered the measure of academic success. Inspection of student performance trends on the various nursing course examinations, in addition to the cumulative Semester I course average, suggested that academic performance of the subjects was very similar to that of the students who did not participate as subjects in this study but who were concurrently enrolled in Semester I.

Data analysis was accomplished by correlating scores on the two research instruments with the measure of academic success, as well as with each other. There was a significant relationship between cognitive development and academic success ( $r=.39$ ,  $p=.01$ ). Cognitive development and cognitive style were also found to be significantly related ( $r=.56$ ,  $p=.001$ ).

This study provided evidence that a relationship did exist among a student's academic success in the first semester of one baccalaureate nursing program and his/her measure of cognitive development and cognitive style. It was suggested that future research be directed at exploring both constructs longitudinally over

the four semesters of the nursing program as well as conducting an investigation of these constructs relative to clinical performance. More information on the relationship between the research variables and attrition obtained through the use of a larger sample size might offer additional diagnostic and prescriptive information to reduce the magnitude of this problem.

Session A-2

ASSESSING THE CONVERGENT AND DISCRIMINANT VALIDITY OF  
COGNITIVE STRUCTURE REPRESENTATIONS OF SCIENCE CONCEPTS

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Methods were developed to assess the convergent and discriminant validity of cognitive structure representations of students' knowledge. These methods were then applied to the assessment of the convergent and discriminant validity of cognitive structure representations for 17 science concepts pertaining to mechanics. Four different data-gathering tasks (free sort, tree construction, word association, concept structuring) and three different scaling methods (latent partition analysis, hierarchical clustering, multidimensional scaling) were employed in obtaining the representations of cognitive structure. The study's results should serve to encourage the wider use of cognitive structure representations of students' science knowledge in science education research.

MATHEMATICAL RELATIONS BETWEEN SCIENCE REASONING SKILLS  
AND SOME VARIABLES ASSOCIATED WITH RATE OF INFORMATION ACQUISITION

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Previous research on mathematical modeling of science information acquisition (Anderson, 1983) is extended here to include the assessment of science reasoning skills as a function of the knowledge-atquisition-rate-equation and some of its component factors. Forty-six high school students (I.Q. range 94 - 139) were administered the BSCS "Processes of Science Test" to assess their performance on a science reasoning dimension; this variable is designated R. The students were also given standard tape-recorded listening tasks for 2, 4, and 8 minute duration to determine how well their recall scores agreed with the predicted values  $N_t$  generated by the model:

$$N_t = N_0 e^{\gamma t} (S_0 e^{-\sigma t} - I_0 e^{-\lambda t}),$$

where  $N_0 e^{\gamma t}$  represents an autogenerative long term memory (LTM) function aiding transfer of information from short term memory (STM) to LTM. The parenthetical factor or modulation factor represents the net stability of STM for holding newly acquired information,  $t$  = time lapse since onset of learning.

Using linear regression analysis, R was related to  $N_t$  and some component parts of the equation with an error of  $p \ll 0.001$ . The resulting equation expressing R as a function of  $N_t$  is:

$$R = 0.623 [N_0 e^{\gamma t} (e^{-\sigma t} - e^{-\lambda t})] t=8 + 13.3;$$

which is an expanded form of the original equation and provides a mathematical link between science process reasoning ability and information acquisition rate. Hence the model is more comprehensive and includes cognitive skill considered significant to scientific reasoning and inquiry. Additional relations were found between R and the gain factor, and the modulation factor.

REFERENCE

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Session A-2

EVALUATING INSTRUCTION: THE HIDDEN CONCEPTUAL CHANGES

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Evaluation of the conceptual changes resulting from second grade students viewing a science education television program about magnets indicated that a reliable objective testing measure did not reveal important conceptual changes that had occurred. The complementary use of an intensive study of a limited number of students indicated that substantial changes in the percentages of correct conceptions and decreases in the percentages of incorrect conceptions followed the viewing of the program. The most important changes were in the predicates students used to describe and predict magnetic interactions and in an increased use of generic concepts such as non-metals in place of object specific concepts, such as rubber bands. The implications are that intensive studies of small numbers of students complement more typical evaluation procedures and provide insight into the effects of instruction that are not otherwise available.



Session A-3

PAPER SET: THE DEVELOPMENT OF SCIENTIFIC LITERACY  
IN SECONDARY SCHOOLS

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This paper set presents initial results of studies being conducted by the Secondary School Improvement Program at the Far West Laboratory and affiliated Research Fellows at the University of Utah.

The first paper, "Life Science Instruction and Its Relationship to Scientific Literacy at the Intermediate Level," sets the stage by presenting an operational definition of scientific literacy and describing initial results of a comprehensive, multivariate, ethnographic study of science instruction in 12 seventh-grade classrooms.

The second paper, "Task and Teacher Characteristics, Student Interest and Achievement in Seventh Grade Life Science," describes the relationships observed between teacher behavior, instructional format and student interest and satisfaction in the same set of 12 seventh-grade science classes, and draws on ethnographic description of specific classes to give examples of these relationships.

The third paper, "The Opportunity Structure of Scientific Literacy in Six High Schools," describes the results of an ethnographic study focusing on the institutional variables (e.g., tracking structure, teacher assignment, material resources), and curricular variables which facilitate and impede the development of scientifically literate high school students.

The fourth paper, "A Historical and Conceptual Analysis of Tracking in the Science Curriculum," will examine the presence and influence of tracking on the goals, materials and instructional procedures in science education.

SCIENCE TEACHING AS A CAREER CHOICE OF  
EIGHTH GRADE STUDENTS

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This research evaluated the desirability of science teaching as a career as rated by eighth grade students. An instrument was developed on which respondents placed their own choice of best and worst possible careers as endpoints on a 10 point scale. Forty-five additional careers, including careers in science teaching, science, and teaching of subjects other than science, were then rated by the students with respect to the endpoints.

Careers in teaching were generally rated low by the respondents, with the exception of physical education and mathematics teaching. The respondent's race and educational aspirations were shown to have a significant relationship (0.05 level) with the ratings of some science teaching careers. Additionally, the relationship between the type of job held by the respondent's parents and the rating of science teaching was also significant in some cases.

UNDERGRADUATE SCIENCE MAJORS: FACTORS  
INFLUENCING CAREER CHOICE

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Approximately 700 freshman students enrolled in introductory biology courses were followed over the four year period of their undergraduate program. Factors that influence initial choices, as well as those that influence successful completion of an undergraduate science major, were examined. Attitudes, aptitudes, and achievement variables that develop during high school as well as college achievement variables were considered. The data were analyzed principally by discriminant analysis.

The variables that discriminated science from non-science groups were achievement variables from the freshman year. Chemistry grade and freshman grade point average were the most discriminating. Physics grades and mathematics grades from courses taken during the sophomore and junior years were less discriminating.

Attitude measures proved to be significant discriminating variables when the sex of the students was considered. Females were more influenced by attitudes, while males appeared to be more achievement oriented.

REASONS POTENTIAL MATH AND SCIENCE TEACHERS  
CHOOSE NOT TO TEACH; WHAT IT WILL TAKE TO  
ATTRACT THEM TO TEACHING AGAIN

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In light of the perceived national need for more science and math teachers, this study was conceived to:

1. identify "teaching oriented" students among freshmen at a mid-western engineering school, who have chosen NOT to become teachers;
2. find out what reasons these "potential" science and math teachers give for deciding not to pursue teaching careers;
3. determine what amelioration of these problems would be necessary for them to no longer be factors which would inhibit students from becoming teachers.

Of a random sample of 110 students drawn from the freshman class of 1982-83, 98 participated fully in the study, five chose not to participate, and seven dropped out of school between the time the sample was drawn and contact was made. Each participant took Holland's Self-Directed Search to determine "teaching orientation" as well as locally made instruments to assess their concerns about teaching.

Results showed "teaching oriented" students to have avoided teaching due to low starting salary, lack of job security, low maximum salaries, not wanting to do the work teachers do, poor job availability, discouragement by family and friends, and low prestige of the profession. Starting salaries of \$21,693 and of \$32,600 for a teacher with a B.A. and 10 years experience were among the changes deemed necessary to make teaching attractive.

REFERENCE

Holland, J. L. The Self-Directed Search Professional Manual. Palo Alto, CA: Consulting Psychologist Press, Inc., 1979.

SENSE OF COMPETENCE IN SCIENCE AS A FACTOR  
IN THE CAREER DECISIONS OF MEN AND WOMEN

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It was hypothesized in this study that men and women develop a belief about their competence in science during the high school years which is based on their participation in certain science courses, their level of performance in those courses, the effort that they expended, and the informal feedback which they received from peers, parents, and teachers about their science work. This sense of competence, in turn, affects the science decisions which these students make when they enter college. Students who believe they have ability in science are more likely to choose a science curriculum in college and to pursue a science career than are those who don't hold such a belief.

A comparison of men and women in the study showed that women performed very well compared to men through high school biology and chemistry. After that point, however, declines in women's participation and performance in science relative to that of men were observed. Also, women felt they worked harder than men did in high school science courses, but they rated their ability lower, even though actual performance was generally better. The results also showed that, in a path model linking high school and college level variables, this sense of competence in science is a central variable.

It was concluded that women's lower sense of competence in science is an important issue in their reduced participation in science courses and careers.

Session A-5

A NATIONAL STUDY OF FACTORS RELATING TO THE  
RETENTION OF WOMEN IN SCIENCE

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National studies of teachers who have successfully motivated high school girls to continue in science were conducted. In addition to analyzing instructional techniques, classroom climates, and teacher-student interactions, a selected sample of former as well as all current students were assessed with a variety of attitudinal, cognitive, and socio-cultural measures.

An analysis of their responses by gender strongly indicated that teacher behavior, instructional style, and classroom climate were related to the level of science anxiety, the source of science attribution, and the type of science attitudes held by young women. In addition, when indicators of locus of control orientation, mode of cognitive style, and spatial visualization ability were analyzed by gender, racial origin, and geographical location of school, it was found that differences were related to regional and racial factors rather than to gender.

Analysis of these results indicates directions for change in teaching behaviors and in curricular materials in secondary schools which could raise the science interest levels of young women. It is anticipated that such changes will increase the number of women enrolling in science majors at college and selecting scientific careers.

Session B-1

THE EFFECTS OF THE SCIENCE METHODS COURSE ON  
STUDENTS' PERFORMANCE DURING STUDENT TEACHING

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Research in science teacher education has focused mainly on the acquisition of skill and method; little emphasis has been placed on studying the effectiveness of training particularly as it pertains to the field experience. The performance of 38 preservice elementary teachers was examined to identify links between methods course preparation and the application of such skill during the field experience. A qualitative research design was used which made use of observation and interview. Considerable variability occurred in the application of training. The factors influencing that application were preparation in science, compatibility with the supervising teacher, the social structure of the school, and the pre-entry attitudes of students.

Session B-1

SCIENCE TEACHERS' BELIEFS ABOUT THE NATURE OF  
SCIENCE AND THE SELECTION, IMPLEMENTATION, AND  
DEVELOPMENT OF INSTRUCTIONAL TASKS

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Progress and advances in and among various fields of science, science education, and technology have, over the past two decades, had the effect of raising society's level of understanding about the scientific enterprise. The focus of the study was an examination of two critical aspects of the scientific enterprise: science teachers and scientific theories.

Over the last two and one-half decades, historians and philosophers of science have focused on the analysis of the structure of scientific theories. The research question, then, is whether or not teachers should make the content and structure of scientific theories a part of their decision-making process in the selection, development, and implementation of instructional tasks.

The purpose of the study was to assess the degree to which teachers made decisions based on scientific theories. Two principal research questions are:

1. What considerations, if any, do science teachers give to the nature of and role of scientific theories in their selection, development, and implementation of instructional tasks?
2. What benefits might occur in instructional tasks if teachers were to include in their decision-making considerations for the nature of scientific theories?

The research employed methodological procedures borrowed from ethnography. Spradley's "Development Research Sequence" and the validation process of triangulation were followed. The research site was a comprehensive four year high school.

Two findings result from the first research question - 1) science teachers give little consideration to scientific theories in their instructional task decision-making, and 2) instructional tasks decisions are dominated by: a) teaching propositional knowledge; b) using select scientific processes as vehicles for teaching



propositional knowledge; c) teaching objectives outlined in curriculum guides; and d) coping with pressures of accountability.

The finding from the second research question is that the philosophy of science can provide a mechanism for restructuring secondary level science curricula because evaluating and interpreting scientific knowledge will necessarily involve learners in an examination of what is known by science, what is not presently known by science, and what may be known by science.

Section B-1

A COST-EFFECTIVENESS ANALYSIS OF INTERVENTIONS  
FOR IMPROVING SCIENCE EDUCATION

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The purpose of this research was to conduct an analysis of the cost-effectiveness of the many interventions proposed for improving science education. Interventions were grouped by objectives sought and analyzed in terms of per pupil annual cost and effectiveness as determined by extant empirical research. For interventions associated with each objective, and for facilitating interventions, matrices display the single interventions in terms of their cost and effectiveness. These analyses highlight the systemic nature of the situation. Single interventions have relatively small potential for substantial impact. There are clusters of interventions with potential for producing substantial improvement in science education. The desired goals must be identified and there must be a willingness to pay a significant but reasonable price.

Session B-2

REASONS GIVEN BY STUDENTS FOR AND AGAINST THE  
FURTHER STUDY OF SCIENCE FOLLOWING COMPLETION  
OF A TWO-YEAR HIGH SCHOOL SCIENCE  
REQUIREMENT AS A BASIS FOR COURSE/  
CURRICULUM CHANGE

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The study has two main purposes: (1) to identify the most important reasons for and against taking science beyond a two-year science requirement; (2) to identify areas of possible change that might increase science enrollment.

The sample of this study was comprised of 306 students who were enrolled (Spring, 1982) in three high schools located in a relatively affluent community in suburban Chicago.

The study revealed that the following reasons for taking science were checked by the highest percentages of science takers:

1. admission to college (85.16%);
2. majoring in a science-related field in college (59.35%);
3. understanding how things work (60.00%);
4. having the aptitude (50.97%).

It also revealed that the following reasons for not taking science were checked by the highest percentages of non-science takers:

1. interest in other subjects (88.08%);
2. lack of interest in science (74.17%);
3. not important for career (68.21%);
4. don't have the aptitude (42.38%).

In addition, the following changes were checked by the highest percentages of all the subjects:

1. if science applications to daily life were emphasized (57.52%);
2. if grades became less dependent on exams (56.88%);
3. more individualization (44.77%);
4. if abstract concepts became understandable (45.42%).

Session B-2

RELATIONSHIP AMONG SELECTED VARIABLES AND THE  
NUMBER OF SCIENCE COURSES COMPLETED BY  
BLACK HIGH SCHOOL SENIORS

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The problem in this study was to identify a set of variables which characterize black secondary science students. The population consisted of a subsample of 3,963 black high school seniors from "The High School and Beyond 1980 Base-Year Survey." Multiple linear regression procedures were used to determine the F-tests. The alpha level was .05.

A significant relationship between socioeconomic variables and science class selection by black high school seniors was indicated. Also, significant relationships were found for locus of control, mother's level of education, mother's expectation, math standardized scores, English grades, and self-concept. The effect of mother having worked accounted for no significance. The effect of self-concept and the effect of locus of control were not related significantly to science class enrollment over and above socioeconomic variables.

REFERENCE

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Session B-2

STUDENTS' SCIENCE RELATED ATTITUDES, SELF EVALUATION  
OF ABILITIES TO DO SCIENCE, AND PERCEPTION OF  
PAST EXPERIENCE FOLLOWING A TWO YEAR HIGH SCHOOL  
SCIENCE REQUIREMENT

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Using multivariate statistical techniques, an investigation was carried out on how high school students who completed two year science requirements compare in their science related attitudes (seven dimensions), self-evaluation of abilities to do science, and perception of past experience with science courses. Two instruments, Test of Science Related Attitudes (TOSRA) and a questionnaire, were administered to 300 students who were enrolled (Spring 1982) in three high schools located in a relatively affluent community in suburban Chicago.

The study revealed an overall highly significant difference between sexes and between students who continue in science and those who do not continue on all the nine dependent variables taken together. In addition, the discriminant analysis revealed that the differences between males and females depend largely on leisure interest in science, self-evaluation of abilities to do science, and perception of past experience. It also revealed that the differences between science and non-science takers depend mostly on enjoyment of science, self evaluation of abilities to do science, and perception of past experience.

TOSRA scales were found to be highly reliable. The discriminant validity of these scales, however, was found to be quite low.

Session B-3

TEACHER RESPONSIBILITY FOR STUDENT SUCCESS AND  
FAILURE AND OBSERVED TEACHING CHARACTERISTICS  
AMONG SECONDARY SCIENCE AND MATHEMATICS TEACHERS

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The study compared selected teacher beliefs and verbal behaviors among secondary science and mathematics teachers. Teacher beliefs included teacher responsibility for student success and failure. These beliefs were measured by the Responsibility for Student Achievement (RSA) Questionnaire which has the locus of control construct as a theoretical basis. Teacher verbal behavior included (1) indirect and (2) direct behaviors and (3) praise and (4) criticism. These behaviors were measured with the Reciprocal Category System (RCS) which is consistent with the methodology of interaction analysis. Comparisons were made on the basis of the following teacher classifications: (1) science/mathematics, (2) junior high/senior high, and (3) teachers of advanced classes/teachers of basic classes.

Only the advanced class/basic class comparisons produced significant differences in either teacher use of praise or criticism. Advanced and basic class comparisons produced significant differences in both teacher beliefs and behaviors. Teachers of basic students assumed more responsibility for student success, assumed less responsibility for student failure, and were more direct in verbal behavior than teachers of advanced students. In comparisons of teacher gender, female teachers were significantly higher in incidences of indirect behavior and combined indirect-direct behavior.

TEACHER INSTRUCTION AND STUDENT PERFORMANCE IN  
BALANCING CHEMICAL EQUATIONS

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The instruction, by four high school teachers, on introductory chemical equation balancing was examined. The content-specific knowledge of the instruction was compared with the knowledge that 42 of their students possessed after the instruction. Students were given a brief examination of their ability to balance chemical equations and were interviewed to determine what relevant knowledge they held. Comparisons were made at three knowledge levels (syntactical, empirical, and theoretical) on selected concepts and propositions necessary for balancing simple chemical equations.

The results indicate that the instruction of the four teachers was heavily weighted towards the syntactic knowledge level. More significantly, these teachers did not stress the relationships between the manipulation of chemical symbols and the empirical and theoretical components of the chemistry from which the equations were derived. All of the students learned to balance the simple chemical equations of the composition-decomposition type and attained the concepts and propositions at the syntactic level of knowledge. However, the majority of the interviewed students failed to develop a consistent or complete understanding of the knowledge at any one level except the syntactic.

Suggestions are made for improving the instruction to facilitate the students' chemical understanding of the equation balancing process.

TEACHER BEHAVIOR AND STUDENT COGNITIVE LEARNING  
IN FIFTEEN BSCS GREEN VERSION BIOLOGY CLASSES

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The purpose of this study was to seek associations between the behaviors of teachers in regular BSCS classrooms and the cognitive learning of their students.

Eight BSCS biology teachers from two public high schools and 353 of their 10th grade male and female students constituted the study population. Seven of the teachers taught two classes in the study; the remaining teacher taught one class. Both high schools were in a large suburban school district.

Perceptions of teacher behavior were collected from students' checklists. A biology test was completed by students as a pre- and post- content measure.

FINDINGS

1. Classes taught by teachers who ranked higher on a direct-to-indirect scale of verbal behaviors showed a higher mean content gain than the classes of teachers who ranked lower on this scale.
2. Classes taught by teachers who ranked higher on a less-to-more inquiry scale showed a higher mean content gain than the classes of teachers who ranked lower on this scale.
3. Teachers who tended to be more indirect in verbal behaviors also tended to be more inquiry-oriented in their procedural behaviors.
4. Specific teacher verbal behaviors that yielded positive association with students' content gain showed that strategies that encouraged student participation were highest.
5. Analysis of specific teacher procedural behaviors showed those higher in association with student content gain were those indicating structured teaching strategies such as pre-planning.



THE EFFECTS OF USING CONCRETE ANALOGIES ON  
FORMAL AND NONFORMAL OPERATIONAL NURSING  
STUDENTS' UNDERSTANDING PHYSIOLOGICAL AND  
PATHOPHYSIOLOGICAL ABSTRACTIONS

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The purpose of this study was to examine the effectiveness of the use of concrete analogies on learning of selected physiological and pathophysiological abstractions in nursing by nonformal and formal operational students. A sample of 65 nursing students was utilized as subjects. The students' cognitive level was determined by the use of the videotape version of a "Classroom Test of Formal Operations." The subjects were classified as either formal operational or nonformal operational and were randomly assigned to either the control group or the experimental group. Both the experimental and control groups had two subgroups: formal and nonformal operational subjects.

A pretest-posttest design was utilized. After a pretest, the subjects had classes on renal processes; hyperosmolar imbalances: nursing implications; hypoosmolar imbalances: nursing implications; and pressure/flow relationships: nursing implications. The experimental group had concrete analogies which utilized perceptible objects and/or relationships representing or resembling abstractions. The control group had classes without the use of concrete analogies.

The data indicated that out of 65 subjects, ranging in age from 21 to 48, that 27 (41.5%) were formal operational and 38 (58.5%) were nonformal operational. Analysis of covariance was utilized and indicated that, for the overall gain scores, the experimental group did significantly better than did the control group (0.000 level of significance). There was no significant difference between the experimental group and control group for the formal learners, except on one subtest (0.026 level of significance). The data suggest rather strongly that the experimental group did significantly better than did the control group for nonformal learners (0.000 level of significance).